MEMORANDUM

TO: Toni Jones, U.S. Environmental Protection Agency

FROM: Eastern Research Group, Inc.

DATE: January 14, 2011

SUBJECT: Summary of Beyond-the-Floor Analysis for CISWI Standards

1.0 PURPOSE

This memorandum summarizes the analysis of control options available for beyond the MACT floor analysis for the final emission standards for Commercial and Industrial Solid Waste Incineration (CISWI) units.

2.0 BACKGROUND

The U.S. Environmental Protection Agency (EPA), under section 129 of the Clean Air Act (CAA), is required to regulate emissions of the following nine pollutants from Commercial and Industrial Solid Waste Incineration (CISWI) units: hydrogen chloride (HCl), carbon monoxide (CO), lead (Pb), cadmium (Cd), mercury (Hg), particulate matter (PM), dioxins/furans (PCDD/PCDF), nitrogen oxides (NO_x), and sulfur dioxide (SO_2).

On December 1, 2000, EPA established new source performance standards and emission guidelines for CISWI units under Sections 111 and 129 of the CAA. In 2001, EPA was granted a petition for reconsideration regarding the definitions of "commercial and industrial waste" and "commercial and industrial solid waste incineration unit." Also in 2001, the United States Court of Appeals for the District of Columbia Circuit granted EPA's voluntary remand, without vacatur, of the 2000 rule. In 2005, EPA proposed and finalized the CISWI definition rule which revised the definitions of "solid waste," "commercial and industrial waste," and "commercial and industrial waste incineration unit." In 2007, the United States Court of Appeals for the District of Columbia Circuit vacated and remanded the 2005 commercial and industrial solid waste incineration definition rule.

In response to the voluntary remand that was granted in 2001, the vacatur, and remand of the CISWI definition rule in 2007, EPA developed these final standards for CISWI units. EPA's solid waste definition rule defines which non-hazardous secondary materials that are used as fuels or ingredients in combustion units are solid wastes under Subtitle D of RCRA. In addition, these final standards include the 5-year technology review of the new source performance standards and emission guidelines required under Section 129 of the CAA. The EPA has developed a series of maximum achievable control technology (MACT) floor and beyond the MACT floor (BTF) options for consideration in developing the final standards.

3.0 SUMMARY OF THE BEYOND-THE-FLOOR ANALYSIS

In developing this final rule, EPA first analyzed the controls available and being used for each subcategory and compared this to the controls necessary for units to meet the MACT floor limits. We then evaluated the different combinations of available emission control technologies and practices, add-on controls different from those required to meet the MACT floor limits, that existing units would have to employ were we to require additional emissions reductions beyond-the-floor levels set forth above. If we determined that any of these additional control options were technically feasible for the units in a subcategory, we then analyzed the costs, nonair quality environmental impacts and benefits associated with adopting the identified control option to determine whether the beyond-the-floor control was reasonable. The following discussions detail this analysis for each subcategory. The supporting tables for this analysis are included in the Appendix, and the data draw from algorithms and emissions estimates presented references 1 and 2.

Incinerators. Existing units in this subcategory are equipped with afterburners, fabric filters (FFs), and wet scrubbers. We estimate that to comply with the existing source MACT floor limits units in this subcategory may require the addition of or improvement of an existing FF for the control of PM, Cd and Pb; wet scrubbers for the control of HCl and SO_2 for many of the units that currently do not have wet scrubbers; activated carbon injection (ACI) system with a FF for the control of D/F and Hg; and in several cases, afterburner retrofits for the control of CO; and selective noncatalytic reduction (SNCR) for NO_X in certain instances. These controls are effective and demonstrated on this subcategory of units for the pollutants they are intended to control (see "Revised CISWI Control Costs Memorandum"). We estimate that some incinerator units in this category will require retrofits of existing control or installation of additional control technologies as set forth above to comply with the MACT floor limits.

Furthermore, as part of our costing and impacts analysis, we evaluated whether existing facilities would choose to cease burning solid waste in incineration units after promulgation of the final CISWI standards if alternative disposal options, primarily diverting waste to a landfill, were less costly. Based on the analysis, we expect that all but three facilities with units in the incinerators subcategory will choose to cease operations once the proposed MACT floor limits are promulgated. The three units that we estimate to remain open will likely add ACI system/FF and one will add SNCR for NO_X control to meet the MACT floor limits. There is no better control beyond the ACI system/FF for D/F, Hg, PM, Cd, and Pb control. The reductions these units will require for meeting the metals emissions will typically need to be greater than 95 percent, therefore necessitating very efficient FF systems. One unit that is not currently meeting the NO_X MACT floor limit must install SNCR to comply with the NO_X floor limit. To achieve further reductions for NO_X, the unit would require another control device, such as SCR, to comply with a beyond-the-floor limit, and would require the other remaining units to also install either SNCR or SCR. The cost of installing and operating the SCR is typically four to five times higher than a comparable SNCR (see "Revised CISWI

Control Cost Memorandum"), and would force this unit to close. In addition to cost considerations, selective catalytic reduction (SCR) is typically used in combustion units such as industrial boilers and process heaters, gas turbines, and reciprocating internal combustion engines (Air Pollution Control Technology Fact Sheet, SCR, EPA-452/F-03-032), and we are not currently aware of any successful application of SCR technology to a waste-combustion unit. We therefore question whether SCR could be successfully applied to incineration units in any case. For acid gas performance, all three units are well below the MACT floor with their existing controls, and addition of wet scrubbers would only offer small incremental improvements in emissions. From a cost perspective, the likely result of requiring wet scrubbers on these units would be closure of these units and diversion of waste to a landfill. Considering these factors, we concluded that beyond-the-floor limits are unreasonable for the incinerator subcategory.

<u>Small remote incinerators.</u> Existing units in this subcategory are typically equipped with an afterburner as the control device, with the facility sometimes employing waste segregation practices to a certain degree, usually to screen out recyclable materials and hazardous waste materials. We received several comments stating that this subcategory has unique climactic, geographic, and wildlife considerations that influence the applicable controls that are available, and commenters also stated that these small remote incinerators are the only viable waste disposal option in certain regions of Alaska. Of primary concern from a technical standpoint are controls that require water to operate or those that have a large space footprint. Water-based controls such as wet scrubbers, SNCR, and even the evaporative cooling section of dry sorbent injection followed by DIFF may pose ice fogging and equipment freezing concerns that could prevent the use of the incinerator.

To achieve the MACT floor limits, more than half of the units in this subcategory will require afterburner upgrades, about two-thirds of the units will require ACI system/FF or FF alone, and most will require a more robust materials segregation plan that removes chlorinated and non-ferrous metal components from the waste stream at these facilities. These controls are the best demonstrated technologies that are technologically feasible at these facilities, and they are sufficient to meet the MACT floor limits. One technology that is beyond-the-floor that is technically feasible would be higher efficiency FF or perhaps the addition of a second FF. However, considering the small amount of emissions that would remain after meeting the MACT floor, we expect the incremental cost effectiveness for a second FF or higher efficiency FF could be extraordinarily high, approaching $500,000/ton.

We have also considered the costs of alternative disposal, and, based on new information obtained during the comment period, we have adjusted our estimates of those costs to be much higher than those we estimated at proposal. Based on the adjusted cost estimates, we have determined that the alternative disposal options exceed the costs of controls necessary to meet the MACT floor limits. In addition, there is still some uncertainty whether alternative disposal is an available option during severe climate events. Our assessment indicates that a beyond-the-floor limit would not be achievable to some facilities due to aforementioned technical issues associated with available controls and would significantly increase costs for others. In either case, we conclude that establishing beyond-the-floor standards would likely result in forced closure of some of the units in this subcategory, but we also believe that some units that would otherwise close due to cost related issues would be forced to operate at a loss because closure may not be an option due to other nonair quality environmental regulations aimed at protecting human health and wildlife. For both the technological and cost related issue discussed above, and because of nonair quality environmental issues, we conclude that there are no reasonable beyond-the-floor alternatives for the small remote incinerator subcategory.

<u>Waste-burning kilns.</u> Existing kilns are currently equipped with various combinations of ESPs, FF, SNCR and DIFF controls. We estimate that kilns may need to add new controls or improve existing controls to meet the MACT floor limits. These include improved FFs to meet the reductions necessary to meet the Cd and Pb limits, activated carbon for D/F and Hg control, and some kilns may need to add RTO to meet the CO limits.

As previously discussed, ACI system/FF are the best technologies available for control of D/F, Hg, PM, Cd and Pb. To meet the floor, the FF will need to be high efficiency, 99 percent in some cases, to meet the MACT floor limit for Cd and Pb. The only further control available would be a second FF, which would result in less than an additional 1 percent reduction of these pollutants. We estimate the cost effectiveness for this to be in the $500,000 per ton range at a minimum. Therefore, there are no further controls to consider as beyond-the-floor options for these pollutants.

For waste-burning kilns, a significant amount of CO emissions can result from the presence of organic compounds in the raw materials (and not only from incomplete combustion). Therefore, good combustion controls and practices are not as effective for waste-burning kilns as for other types of combustion units, and may not be enough for units to meet the MACT floor CO limits. Oxidation catalysts have not been installed on waste-burning kilns, and we believe they may not be as effective on waste-burning kilns as they are on other sources due to plugging problems. Specifically, the catalyst bed can become plugged or blinded with dust, thereby covering up catalyst reactive sites necessary to oxidize CO, which reduces the effectiveness of the unit. To maintain the effectiveness of the catalyst, the unit may require shutting down more frequently to replace the catalyst, which reduces productivity of the unit and increases catalyst costs. To make an oxidation catalyst feasible, it may be necessary to also use multiple FF in series upstream of the catalyst which, as described above, is a very costly measure. The only effective CO control for significant CO reductions we could identify for waste-burning kilns is a regenerative thermal oxidizer (RTO), and we expect over half of the units will need to install a RTO to meet the MACT floor limits. As a beyond-the-floor option, setting a CO limit at a level that most of the remaining waste-burning kilns would also require RTO could be considered, although we doubt that some of the units requiring RTO to meet the MACT floor emission limit for CO would be able to further reduce their emissions to that same extent. Furthermore, the cost and energy consumption for these additional RTO make this an impractical choice. Therefore, as there are no other controls which could be applied to further reduce CO emissions from these units and additional RTOs would be ineffective from a cost and energy impacts perspective, we could not identify a beyond-the-floor option for CO.

We expect that waste-burning kilns will install scrubbers to meet the MACT floor emission limits for HCl and SO_2. The floor limits for HCl are at the levels of quantification of the test method used to determine compliance. Therefore, there are no additional measures that could be employed to quantify any further reductions in HCl emissions beyond that of the MACT floor limit. The only other option for further HCl and SO_2 control would be addition of a dry sorbent injection system in series with the wet scrubber. However, this would approximately double the costs for acid gas control, with only about a 30 percent incremental reduction in SO_2 emissions and no measurable reduction in HCl emissions. As a result, no beyond-the-floor options for acid gases from waste-burning kilns exist because we cannot quantify further HCl reductions, and the beyond-the-floor options for SO_2 reductions are unreasonable due to the cost of the additional controls in conjunction with the limited benefits of such controls.

The demonstrated control technology for NO_x control on waste-burning kilns is SNCR. In fact, several of the kilns are already equipped with this technology and are able to comply with the NO_x MACT floor limit. We estimate that other kilns may require the addition of SNCR to meet the MACT floor limits for NO_x. One kiln will require an SNCR that is optimized to the capabilities of the technology to meet the MACT floor limits for NO_x. For this unit to be able to achieve an even lower NO_x limit would likely require another technology. As discussed above, SCR is another technology that is used by some combustion sources to reduce NO_x emissions; however, SCR is a catalyst technology that has not been demonstrated to work effectively on cement kilns (or waste-burning kilns) in the United States. We believe that SCR is not effective on waste-burning kilns due to difficulties operating SCR in applications where there is significant PM or sulfur loading in the gas stream. These two gas stream constituents can reduce catalyst activity, and lower the resulting effectiveness of the SCR, through catalyst poisoning and blinding/plugging of active sites by ammonia sulfur salts (formed from sulfur in the flue gas with the ammonia reagent) and PM (Air Pollution Control Technology Fact Sheet, SCR, EPA-452/F-03-032). We could not identify any other controls beyond SCR and SNCR, alone or in tandem, to reduce NO_x emissions from waste-burning kilns. We believe that SCR is not technically demonstrated on kilns currently and may not be technically feasible. For these reasons, we are not selecting a limit for NO_x that is beyond-the-floor for the waste-burning kiln subcategory.

<u>Liquid waste ERUs.</u> Existing units in this subcategory are equipped with flue gas recirculation in a couple cases, and some settling chambers for particulate control in a couple other units. We anticipate units within this subcategory may need to install FF, CO catalyst, and SNCR to meet the MACT floor limits. As discussed earlier, FFs are the best control available for PM, Cd, and Pb control. The only further control available would be a second FF or a very high efficiency FF. The metals emissions from these

units is very low to begin with, so the only incremental reductions would be in PM. This would result in perhaps an additional 10 percent reduction in emissions at almost double the cost of current particulate controls. As mentioned before, we anticipate cost effectiveness for this to be in the $500,000 per ton range at a minimum. Likewise, SNCR is the best demonstrated technology being applied to waste combustion units for NO_x control. As discussed earlier, SCR has been used in some boiler applications, but SCR costs are approximately four to five times those of SNCR, for only an additional 30 percent reduction from the baseline. Furthermore, we observe that SCR has not been demonstrated to work effectively on waste combustion units in the United States. Carbon monoxide control for liquid waste ERUs could also be achieved by using a RTO, but at a far greater energy requirement, notably in natural gas consumption, with comparable control efficiency as the CO catalysts that we expect some units will need to install to meet the MACT floor CO limits. Therefore, we conclude that additional beyond-the-floor CO control would be unreasonable for this subcategory.

Additional D/F and Hg control could be achieved using ACI with another FF. However, the baseline emissions for these pollutants are already very small, with only marginal additional emissions reductions available if additional controls were being used. Therefore, beyond-the-floor limits for these pollutants will not be reasonable from a cost effectiveness perspective.

We also considered whether it is reasonable to go beyond-the-floor with respect to SO_2 for this subcategory. In this case, the DIFF control technology could be applied to these units to reduce SO_2 emissions by about 70 percent with co-control of HCl (90 percent) as well as PM, Cd, and Pb. Most of these units will already require the addition of a FF to meet the MACT floor limits, so the cost of going beyond-the-floor for these units would entail the dry sorbent injection components of the control device. For the units that do not require FF to meet the floor, the additional costs would involve the entire DIFF control device. The total cost for applying the relevant controls to all the units is approximately $4.8 million per year in annualized capital and operating costs for SO_2 control beyond-the-floor. The reduction in emissions of SO_2 is approximately 2,300 tpy, based on the baseline emissions estimate and a 70 percent reduction and accounting for SO_2 emissions from electricity generation needed to power the controls. It is worth noting that the baseline estimates and MACT floor calculations for this subcategory are based on data from the only unit for which we have SO_2 data in this subcategory. This unit has a baseline SO_2 concentration of 641 ppm, which has been applied to the other five liquid ERUs as an estimated baseline concentration. The HCl concentration for this unit is about 4 ppm, so co-benefit emission reductions are significantly less than the SO_2 emission reductions. Because we are basing these analysis off of data from a single unit within the subcategory, we realize that there is a large margin of uncertainty on the control requirements within this source category and the potential for SO_2 emissions reductions at the beyond-the-floor level.

To get a better idea of the potential cost effectiveness for a beyond-the-floor limit for SO_2, we also looked at the costs and emissions reductions solely for the unit which we have data for to determine the cost effectiveness of control for this unit. In this case, the additional cost of the dry injection system (the unit already requires a FF to meet the MACT floor limits) is about $567,000 per year, with an estimated emissions reduction of 103 tpy of SO_2(and minor HCl reduction) adjusted for SO_2 emissions from electricity generated to power the controls. This results in an incremental cost effectiveness of $5,500 per ton of SO_2 control beyond-the-floor. While this number is generally within the cost effective range we find reasonable, we are not adopting a beyond-the-floor limit for SO_2 given the uncertainty associated with this number, the fact that we cannot adequately estimate the costs for other units in the subcategory, and because the controls required for HCl may actually reduce SO_2 more than is required based on the SO_2 standard alone such that the actual cost effectiveness of the beyond-the-floor option is not in line with the estimate.

Regarding co-control for PM, the fact that four of the six liquid waste ERUs will likely require FF to meet MACT floor limits for Cd and Pb means that going beyond-the-floor using DIFF controls would only net additional PM control on the two remaining units. The FF portion of the control costs for these two units is approximately $1.1 million per year with an estimated PM reduction of fewer than five tpy, which translates into an incremental cost-effectiveness of about $230,000 per ton for additional PM control. Based on our analysis and realizing the high degree of uncertainty regarding costs, emissions reductions and resulting cost-effectiveness for this particular CISWI subcategory, we have concluded that requiring beyond-the-floor controls on these units is unreasonable.

<u>Solid waste ERUs.</u> Existing units in this subcategory are equipped with various combinations of ESPs, FF, scrubbers, SNCR spray towers, and DIFF. We anticipate units within this subcategory may need to install or improve different combinations of ACI system/FF, DIFF, FF, LBMS, CO catalysts, and wet scrubber control technologies to meet the MACT floor limits. As discussed earlier, a FF is the best control available for PM, Cd, and Pb control. The Cd and Pb reductions necessary are greater than 90 percent in many cases, indicating that units will likely require highly efficient FF to meet the limits for these pollutants and PM. Therefore, beyond-the-floor limits for PM, Cd and Pb would likely necessitate a second FF, essentially doubling the cost for little additional reduction in emissions. Furthermore, the ACI system is the BAT for reducing D/F and Hg emissions. The D/F reduction necessary for some of these units approaches 99 percent, indicating that beyond-the-floor limits that are more stringent than the MACT floor limits may not be achievable by the control technology.

In certain cases, units may require DIFF and wet scrubbers in series to meet acid gas limits. There are no additional controls that could be implemented in these cases to further reduce acid gas emissions. Carbon monoxide control for solid waste ERUs could also be achieved by using a RTO, but likely at a far greater energy requirement (specifically natural gas) with comparable control efficiency as the CO catalysts that we expect some units will need to install to meet the MACT floor CO limits. Therefore, we conclude that additional beyond-the-floor CO control would be unreasonable for this subcategory due to additional cost and energy impacts.

The demonstrated control technology for NO_X control on ERUs is SNCR. In fact, some of the ERUs are already equipped with this technology. A couple of the units appear to comply with the NO_X MACT limit because they already have an SNCR in place. As mentioned earlier, SCR is another technology that is used by some combustion sources to reduce NO_X emissions. However, SCR costs can be about four to five times more costly than SNCR. Furthermore, we observe that SCR has not been demonstrated to work effectively on waste combustion units in the United States. We realize that the industrial sectors that use units within this CISWI subcategory are typically wood and forest product industries, sectors that have suffered particular economic hardship. We are attempting to make sure that the regulatory requirements are being satisfied, while minimizing adverse economic impact wherever possible. Since there remain some questions about a demonstrated control beyond the control used to meet the MACT floor limits, and some units are already utilizing SNCR to meet the MACT limit, coupled with the fact that the potential beyond-the-floor technology is significantly more expensive, we are not selecting a limit for NO_X that is beyond-the-floor for the solid waste ERU subcategory.

New Units. We have concluded that only two of the CISWI subcategories may see any new units within the immediate future, primarily due to replacement of old units. These two subcategories are the incinerator subcategory and the small remote incinerator subcategory. While facilities may find alternative disposal options are available, we are cognizant of the fact that, for these subcategories, there may be instances where alternative disposal options are unavailable, and a new incineration unit may be required. For incinerators, we estimate units may require a combination of the ACI system/FF, SNCR, and wet scrubbers to achieve the new source MACT floor limits. As discussed above for existing incinerators, there are no control technologies demonstrated or reasonably cost-effective that we could consider at this time that would perform better or be more cost-effective than those being used to meet the new source MACT floor limits. Therefore, we have concluded that no beyond-the-floor emission limits should be selected for new incinerators. For small remote incinerators, we anticipate new sources will have an afterburner installed to achieve the CO limit and that the afterburner will also be equipped with low NO_X burners, require waste segregation for ferrous and non-ferrous metals and chlorinated plastics, and likely require ACI system/FF to meet the new source MACT floor limits. As discussed above for existing small remote incinerators, there are technical issues with any control technologies that require water for operation for this subcategory of unit. As a result, there are no additional or better control technologies available other than those being used to meet the new source MACT floor limits for the small remote incinerator subcategory.

REFERENCES

1. "Revised Compliance Cost Analyses for CISWI Units" Memorandum from Eastern Research Group, Inc. to Toni Jones, U.S. Environmental Protection Agency. January 12, 2011.

2. "Revised Baseline Emissions and Emissions Reductions Estimates for Existing CISWI Units" Memorandum from Eastern Research Group, Inc. to Toni Jones, U.S. Environmental Protection Agency. January 12, 2011.